Science and Language for English Language Learners in Relation to Next Generation Science Standards and with Implications for Common Core State Standards for English Language Arts and Mathematics

Okhee Lee[1], Helen Quinn[2], and Guadalupe Valdés[3]

The National Research Council (2011) released "A Framework for K–12 Science Education" that is guiding the development of the Next Generation Science Standards, which are expected to be finalized in early 2013. This article addresses language demands and opportunities that are embedded in the science and engineering practices delineated in the Framework. By examining intersections between learning of science and learning of language, the article identifies key features of the *language of the science classroom* as students engage in these language-intensive science and engineering practices. We propose that when students, especially English language learners, are adequately supported to "do" specific things with language, both science learning and language learning are promoted. We highlight implications for Common Core State Standards for English language arts and mathematics.

Keywords: bilingual/bicultural; language comprehension/development; policy analysis; science education

Common Core State Standards (CCSS) for English language arts and literacy and for mathematics (Common Core State Standards Initiative, 2010a, 2010b) have been adopted by most states and will affect instructional practice, curriculum, and assessment across the nation. The National Research Council (NRC, 2011) document "A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas" (hereafter referred to as "the Framework") is the product of a committee of experts charged with developing a consensus view of what is important in K–12 science education grounded in an extensive review of the literature on science learning. Furthermore, this document is designed to guide the work of 26 lead states in developing Next Generation Science Standards (NGSS), a project coordinated by Achieve, Inc. The first draft of NGSS was released for public input in late spring 2012, the second draft close to the final form was released in January 2013, and NGSS are expected to be finalized in early 2013. We use the Framework as the base of our discussion in this article as NGSS faithfully follow the Framework as the foundation. Our purpose is not to reexamine the decisions made for the Framework or NGSS, but rather to explore and highlight their implications for English language learners (ELLs) in the science classroom.

This article discusses language learning challenges and opportunities that will emerge as ELLs engage with NGSS.[1] First, the article provides a brief overview of the Framework with a focus on language-intensive science and engineering practices (NRC, 2011). Second, it describes the literature on language in science learning and teaching. Third, it provides a perspective on second language acquisition and pedagogy. Fourth, by examining intersections between learning of science and learning of language, it identifies key features of the *language of the science classroom* as students engage in language-intensive science and engineering practices. Finally, it offers implications for research and policy.

The Framework refines what it means to promote learning science by moving away from prior approaches of detailed facts or loosely defined inquiry to a three-dimensional view of science and engineering practices, crosscutting concepts, and disciplinary core ideas. We argue for a parallel redefinition of what it means to support learning language in the science classroom by moving away from the traditional emphasis on language structure (phonology, morphology, vocabulary, and syntax) to an emphasis on language use for communication and learning. All students face language and literacy challenges and opportunities that are specific to science; such challenges and opportunities are

[1]New York University, New York, NY
[2]SLAC National Accelerator Laboratory, Menlo Park, CA
[3]Stanford University, Stanford, CA

Educational Researcher, Vol. 42 No. 4, pp. 223–233
DOI: 10.3102/0013189X13480524

Table 1
Three Dimensions of the Science Framework

Scientific and Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
1. Asking questions (for science) and defining problems (for engineering) 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information	1. Patterns, similarity, and diversity 2. Cause and effect: Mechanism and explanation 3. Scale, proportion, and quantity 4. Systems and system models 5. Energy and matter: Flows, cycles, and conservation 6. Structure and function 7. Stability and change	Physical Sciences PS 1: Matter and its interactions PS 2: Motion and stability: Forces and interactions PS 3: Energy PS 4: Waves and their applications in technologies for information transfer Life Sciences LS 1: From molecules to organisms: Structures and processes LS 2: Ecosystems: Interactions, energy, and dynamics LS 3: Heredity: Inheritance and variation of traits LS 4: Biological evolution: Unity and diversity Earth and Space Sciences ESS 1: Earth's place in the universe ESS 2: Earth's systems ESS 3: Earth and human activity Engineering, Technology, and the Applications of Science ETS 1: Engineering design ETS 2: Links among engineering, technology, science, and society

amplified for ELLs and for other English speakers with limited standard English language and literacy development. We propose that when students, especially ELLs, are adequately supported to "do" specific things with language, both science learning and language learning are promoted. Our conceptualization of the *language of the science classroom* could inform the fields of science education, second language acquisition/English for speakers of other languages (ESOL)/English as a second language (ESL), and teacher preparation and professional development as the NGSS shape instructional practice, curriculum, and assessment in the coming years. Furthermore, this conceptualization could be applicable to other subjects, especially CCSS for English language arts and literacy and for mathematics. For example, the conceptual issues discussed in this article are used for the "Framework for English language proficiency development standards corresponding to the Common Core State Standards and the Next Generation Science Standards" (Council of Chief State School Officers [CCSSO], 2012).

Next Generation Science Standards with a Focus on Science and Engineering Practices

The Framework defines science learning as having three dimensions: (a) science and engineering practices, (b) crosscutting concepts, and (c) core ideas in each science discipline (see Table 1). The central content of the Framework document is a detailed explanation of what is intended in each dimension; how the three dimensions should be integrated in curriculum, instruction, and assessment; and how these dimensions progress in sophistication across K–12 grades. The meaning of the term *inquiry-based science* is refined and deepened by the explicit definition of the set of science and engineering practices. These practices are presented both as a representation of what scientists do as they engage in scientific inquiry and as a necessary part of what students must do both to learn science and to understand the nature of science. Furthermore, although both science learning and language learning demands increase as students progress across the grade levels, in this article we highlight general features and strategies that are common across grade levels. Much further work will be needed to develop grade-by-grade discrimination of how these general features and strategies are realized.

Engagement in any of the science and engineering practices involves both scientific sense-making and language use. The practices intertwine with one another in the sense-making process, which is a key endeavor that helps students to transition from their naïve conceptions of the world to more scientifically based conceptions. Engagement in these practices is also language intensive. In particular, we focus on four of the eight practices described in the Framework: (no. 2) developing and using models, (no. 6) constructing explanations (for science) and designing solutions (for engineering), (no. 7) engaging in argument from evidence, and (no. 8) obtaining, evaluating, and communicating information. These four practices are selected for the following reasons (see CCSSO, 2012 for all eight practices).

First, these practices are interrelated, in that each is used to support effective engagement in the others. For example, *argumentation from evidence* requires students to develop both mental and diagrammed *models* that clarify their thinking about the phenomenon or system under investigation and to construct *model-based explanations* using evidence (data and observations), logic, and verification. Argument is essential to support or critique a model or an explanation as well as its success or failure in explaining evidence about the phenomenon or system. Clearly, students must *obtain, evaluate and communicate information* as they engage in the process of constructing and critiquing explanations.

Second, these practices are language intensive and require students to engage in classroom science discourse (see literature review by G. Kelly, 2007). Students must read, write, view, and visually represent as they develop their models and explanations. They speak and listen as they present their ideas or engage in

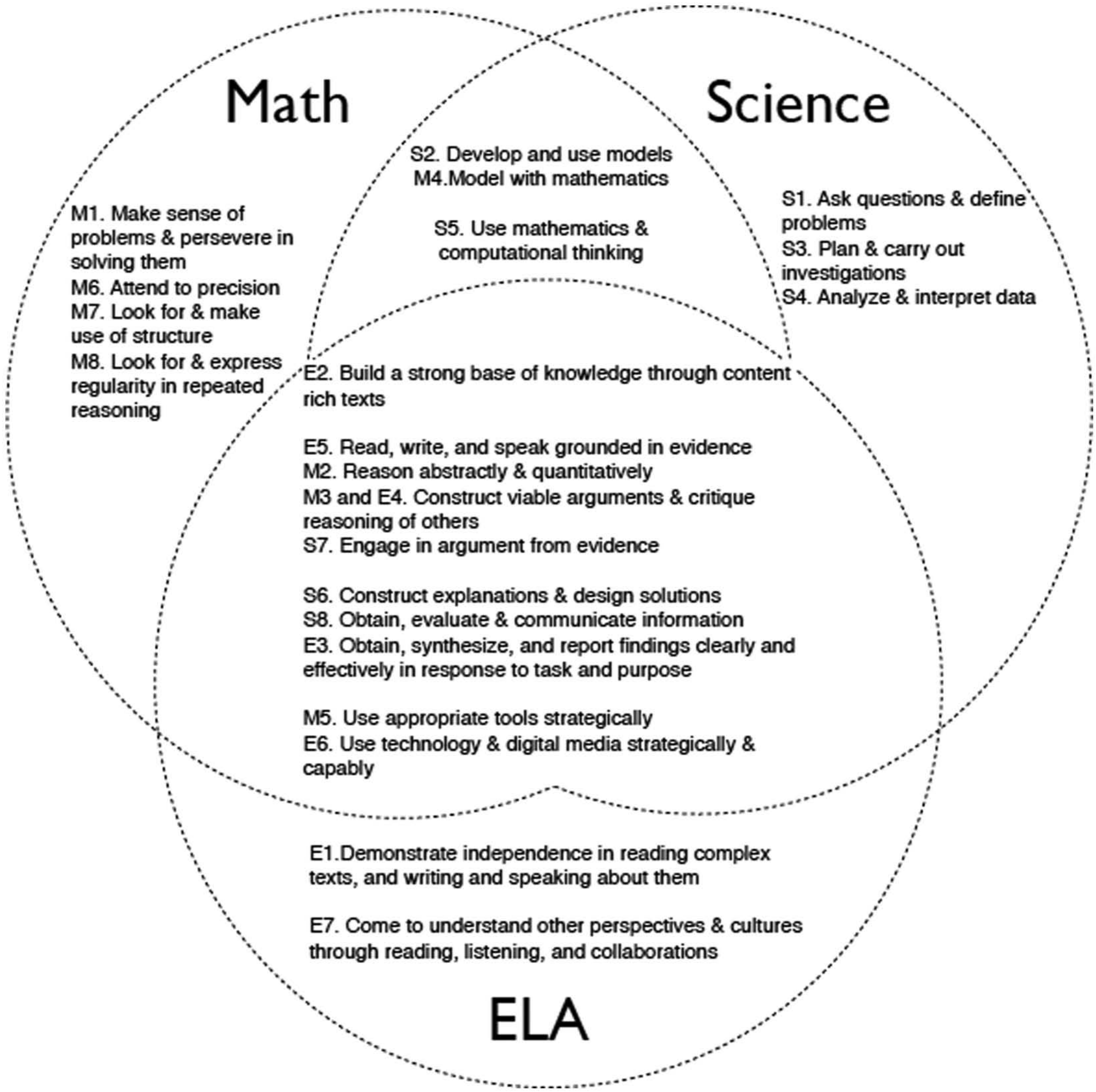

FIGURE 1. *Relationships and convergences found in the Common Core State Standards for Mathematics (practices), Common Core State Standards for English Language Arts and Literacy (student portraits), and the Science Framework (science and engineering practices)*
The letter and number set preceding each phrase denotes the discipline and number designated by the content standards. The Science Framework is being used to guide the development of the Next Generation Science Standards.

reasoned argumentation with others to refine their ideas and reach shared conclusions. These practices offer rich opportunities and demands for language learning at the same time as they promote science learning.

Third, these practices are generally less familiar to many science teachers and require shifts for science teaching (Windschitl, Thompson, & Braaten, 2011). Teachers implementing these practices need both understanding of the practices and strategies to include all students regardless of English proficiency. The classroom culture of discourse must be developed and supported. Teachers need to ensure that all voices are respected, even as the process reveals limitations of a model or explanation, or “flawed” use of language.[2] For all students, the emphasis should be on making meaning, on hearing and understanding the contributions of others, and on communicating their own ideas in a common effort to build understanding of the phenomenon or to design solutions of the system being investigated and discussed.

Finally, the requirement for classroom discourse and the norms for this behavior are to a great extent common across all the science disciplines, and indeed across all the subject areas. The convergence of disciplinary practices across CCSS for mathematics and English language arts and literacy and NGSS are highlighted in Figure 1.

In short, as science classrooms incorporate the discourse-rich science and engineering practices described in the Framework, they will become richer language learning environments as well as richer science learning environments for all students. Engaging ELLs in these practices merits special attention, because such engagement can support both science and language learning.

Language in Science Learning and Teaching

To support students' engagement in the science and engineering practices highlighted in the previous section, teachers need a nuanced view of how language is used to construct and communicate meaning in science. Contemporary research on language in science learning and teaching highlights what students and teachers *do* with language as they engage in science inquiry and discourse practices (see literature review by Carlsen, 2007; G. Kelly, 2007).

Systemic Functional Linguistics Perspective

Systemic functional linguistics provides one perspective on how language is used in science learning. Halliday and Martin (1993) framed what they termed "the linguistic register"[3] of science classroom communication as a resource for meaning-making, not as a rigid set of conventions or a system of rules to be learned. Halliday (2002) argued that students must develop and understand the linguistic tools for meaning-making in science as comprising a unique linguistic register. This register provides tools for understanding what people are doing, what their relations are to each other, and how they are using language in the context of making scientific meaning.

Although the disciplinary language of science may seem quite different from everyday discourse, Halliday and Matthiessen (2004) argued that science and everyday discourse are dialogically complementary, interrelated, and synergistic and represent a fundamental continuity that provides different ways of depicting a common reality. Thus, the goal of learning the language of science is not to replace everyday language but to provide different tools for different communicative purposes. Teachers can support their students through classroom practices that make the features of the disciplinary language of science explicit, so that students build linguistic awareness and become comfortable using the disciplinary language for linguistically challenging tasks (Fang & Schleppegrell, 2008).

Discourse and Social Practice in the Science Classroom

Science education researchers have considered how discourse becomes part of the social practice of the science classroom (see literature review by G. Kelly, 2007). In perhaps the most widely cited work on how discourse is constructed in science classrooms, Lemke (1990) argued that discourse should be seen as "differentiated speech" that different groups of people and texts bring to science. For Lemke, the greatest challenge science teachers face is how to support students in building connections across differentiated speech forms, from everyday language to disciplinary discourse. In a similar vein, Gee (1990) proposed that to become competent users of the genre of classroom science discourse (which he distinguished from the genre of research science discourse), students must adopt certain communicative practices, such as those accepted for evaluating claims and representing scientific principles. These practices allow the speaker to be recognized as possessing scientific authority.

Using these conceptual ideas, a number of researchers have developed intervention studies to support teachers' and students' use of discourse and social practice in developing scientific understanding and engaging in scientific practices. For example, Engle and Conant (2002) identified four principles to foster productive disciplinary engagement in the classroom: problematizing content, giving students authority, holding students accountable to others and to disciplinary norms, and providing relevant resources. In a similar line of research, Cornelius and Herrenkohl (2004) mapped students' epistemological development in science onto the dynamic interactions of talk, text, other representations, and social interactions that took place in science classrooms. As another line of research, Windschitl et al. (2011) developed discourse tools and scaffolding to support novice science teachers in developing elements of expertlike teaching, with the greatest gains made in pressing their students for evidence-based scientific explanations through modeling and representations of challenging science concepts.

Language in Science Learning with ELLs

Although the research on discourse and social practice in the science classroom, as discussed above, has addressed the learning needs of all students, another area of research on language in science learning has focused on students who have traditionally been marginalized in science, including ELLs. This research has highlighted the importance of considering both the linguistic challenges and resources that ELLs and other traditionally marginalized students bring to the science classroom.

In perhaps the earliest line of research on science and language learning with ELLs, Warren, Rosebery, and colleagues (e.g., Rosebery, Warren, & Conant, 1992; Warren, Rosebery, & Conant, 1994) engaged students in scientific experimentation as a process of learning to appropriate scientific discourse and construct scientific meaning. The work focuses on the linguistic, cultural, conceptual, and imaginative resources that ELLs bring to the science classroom that can serve as intellectual resources for learning scientific knowledge and practices. In another longstanding line of research, Lee and colleagues (e.g., Lee, Buxton, Lewis, & LeRoy, 2006; Lee & Fradd, 1998) highlighted the importance of developing congruence between students' cultural and linguistic experiences and the specific demands of particular academic disciplines such as science. The work focuses on the link between the home and the academic discipline, especially when the two domains contain potentially discontinuous elements. In an emerging line of work, Brown (Brown, 2006; Brown & Ryoo, 2008) emphasized making the norms of scientific language explicit as a way to bridge the apparent cultural divide between learning to use the language of science and maintaining cultural identity. With ELLs, the work first focuses on discussion of scientific concepts in everyday English and then provides instructional scaffolds to help students convert the concepts into scientific language.

New Standards and Second Language Acquisition with ELLs

As we have pointed out above, the implementation of the CCSS and NGSS will affect instructional practice, curriculum, and assessment across the nation. Title III of the Elementary and Secondary Education Act (ESEA) will also require the states that have adopted these standards to develop English language proficiency development (ELPD) standards (see CCSSO, 2012, as one approach), ELPD assessments that are aligned with those standards, and annual measurable achievement objectives (AMAOs) for English language proficiency. State policies to meet existing federal requirements have many implications for the science education community. Important as the work on language and science has been to date, it is vital that, going forward, science educators and science education researchers understand the key assumptions made about second language acquisition (SLA) and second language pedagogy that inform the politics, policies, and practices surrounding the education of ELLs.

Here we present a brief discussion of first and second languages and their acquisition that emphasizes pragmatic, textual, and sociolinguistic competencies in SLA (Bachman, 1990; Canale & Swain, 1980). The view presented here is much broader than other familiar conceptualizations of language that are typically represented in English language development standards and assessments, both of which are primarily focused on grammatical competence (phonology, morphology, vocabulary, and syntax).

"Doing" Things With Language

Children naturally acquire both the ability to use language and implicit knowledge about not only the structure of that language (e.g., the sound patterns of words, the order of words) but also the conventions (e.g., when to speak or not speak and what to say to whom). By the time they arrive in school, children are skilled users of the variety of language functions used in their home and community. They *can do* many things with language. For example, they can argue with their siblings, complain, disagree, ask and answer questions, and make their needs and feelings known.

Children who are speakers of social or regional varieties of English that are generally referred to as "non-Standard English" may not have mastered the school-accepted ways of speaking to their teacher and classmates, asking and answering questions, or participating effectively in classroom interactions. However, these students can understand their teachers' explanations and instructions as well as what is said to them by their peers. They arrive at school ready, in varying degrees, to learn how *to do* many more things with their language and—from the perspective of systemic functional linguistics—to learn about the ways in which different aspects of language can be used skillfully to create textual meanings.

Students who are referred to as ELLs arrive at school with a well-established first language but at many different levels of English language development. Some may have little or no comprehension of English, whereas others may comprehend even subtle meanings but express themselves hesitantly, with simple and "flawed" language. However, when supported appropriately, most ELLs are capable of learning subjects such as science through their emerging language and of comprehending and carrying out sophisticated language functions (e.g., arguing from evidence, providing explanations) using less-than-perfect English. They *can do* a number of things using whatever level of English they have and can participate in science and engineering practices. By engaging in such practices, moreover, they grow in both their understanding of science and their language proficiency (i.e., capacity to do more with language).

Theories of Second Language Acquisition and Pedagogy

Second languages are acquired every day around the world in naturalistic contexts—outside the classroom—by individuals of different ages and backgrounds when interacting with speakers of that language with whom they need to communicate. According to Wong Fillmore (1992), two conditions are necessary to acquire a second language: (a) learners must have available to them speakers of the language who know the language well enough to provide both access to it and help in learning it, and (b) the social setting must bring learners and target language speakers into frequent enough contact to make language learning possible. In the case of children who arrive in the United States not speaking, or with limited, English, these conditions are seldom met. In many schools, ELLs have little contact with their English-speaking peers. Moreover, language is seen as an academic subject that has to be "taught" and "learned." Thus, "teaching" English to ELLs is seen primarily as the responsibility of specially trained language specialists, such as ESL and ESOL teachers.

Second language acquisition (SLA). Broadly, SLA theories divide into two perspectives (Zuengler & Miller, 2006). Traditional or "mainstream" SLA has viewed language learning as an individual cognitive task. Representatives of this perspective are what Johnson (2004) categorizes as information-processing approaches to SLA, including Gass and Selinker's model of SLA acquisition (2001) and Long's interaction hypothesis (1983, 1996). Progress in students' acquisition of the linguistic system is measured primarily by performance on discrete-point tests of grammatical forms.

The other, more socially oriented view of SLA, adopted in this article, is concerned with understanding how speakers of one language become users (speakers, listeners, writers, readers) of a second language. For researchers who ascribe to this view, the goal of second language learning is to use that language in order to function competently in a variety of contexts for a range of purposes. Such perspectives include Vygotskian sociocultural theory (Lantolf, 2000, 2006) and language socialization perspectives (Duff, 1995, 2002).

Second language pedagogy. Over 25 centuries of second language teaching (L. G. Kelly, 1969), there have been a series of pendulum shifts, debates, innovations, and controversies. In general, research on second language teaching (Ellis, 2005; Norris & Ortega, 2000, 2006) has been carried out primarily with adults in post-secondary settings.

Like the two perspectives on SLA, second language pedagogies can generally be classified as following one of two approaches: the structural and the experiential (Stern, 1990). Structural approaches based on traditional or mainstream SLA focus on "teaching" specific language elements (e.g., vocabulary, pronunciation, grammatical forms), assuming that these elements can be ordered and sequenced in a way that over time will lead to grammatical accuracy, greater complexity, and increased fluency. An example of such an approach is forms-focused instruction described by Long (1991) that is typical of most foreign language and ESL instruction and primarily follows a grammatical syllabus (e.g., modal verbs, present progressive, past tense, vocabulary lists), although also incorporating "communicative" activities using these forms.

Experiential approaches to teaching language, adopted in this article, are based on the socially oriented view of SLA. These approaches focus on supporting students' ability to do things with language, engaging them in purposeful activities, and providing them with opportunities for language use. An example of such an approach is task-based instruction that follows a curriculum of tasks (e.g., activities involving information gaps of various types in both written and oral language) around which students engage in actual communication (Pica, 2008).

Intersections between Learning of Science and Learning of Language

It is the perspective of this article that the opportunity for language development through use in context can be a language learning experience at the same time as it can be a science learning experience, provided that teachers understand how to include and support ELLs regardless of their levels of English proficiency. In this article, we identify key features of the *language of the science classroom* as students engage in language-intensive science and engineering practices. Before explaining our conceptualization, we examine one current approach to integrating the teaching of language and the teaching of science, *content-based language instruction.*

Content-Based Language Instruction

Content-based language instruction, at its best, integrates the teaching of language and the teaching of academic subjects (Scarcella, 2003; Schleppegrell, 2004; Snow, 2001). It was introduced to counter traditional "content-less" language instruction that focused primarily on forms and minimized the importance of meaningful and authentic use in the acquisition of language (Brinton, Snow, & Wesche, 1989). Originally taught by language specialists, including ESL and ESOL teachers, content-based language instruction was intended to provide students with increased motivation in subject matter as well as opportunities to experience larger discourse-level features and social interaction patterns essential to language use. However, ESL or ESOL teachers' inadequate content knowledge in multiple academic subjects has limited the success of this approach.

More recently, content-based language instruction has shifted to a "sheltered" model, in which content area classes for ELLs are taught by content area teachers with some training in language pedagogies, usually of the traditional type. Teachers are encouraged to focus on *both* content objectives *and* language objectives (Echevarria & Short, 2006; Echevarria & Vogt, 2008). Content-based language instruction is a valuable attempt to bring together subject matter instruction and second language instruction. Perhaps because content-based language instruction emerged within traditional language pedagogy, the attention of content area teachers is often directed at the study and practice of forms and language items such as vocabulary, phrases, or sentence frames.

Most science teachers today are likely to have learned about language primarily in these terms. When they are told that they must help students to acquire "academic language," there is much confusion about what this means. Indeed, this term is used variously by different scholars and professional development specialists.[4] Should they teach words from Coxhead's (1998) Academic Wordlist (e.g., assemble, prohibit, simulate) or should they limit themselves to the technical vocabulary of science? Should they be concerned with agreement of verbs and the correction of nonstandard forms (e.g., he done come) or should they model ways in which "real" scientists talk to each other?

In this article, we argue for two shifts: (a) a shift away from both content-based language instruction and the sheltered model to a focus on language-in-use environments and (b) a shift away from "teaching" discrete language skills to a focus on supporting language development by providing appropriate contexts and experiences. We envision science teachers who create carefully planned classrooms where students engage in science and engineering practices, such as evidence-based arguments and explanations of phenomena or systems. In such classrooms, ELLs are not left to sink or swim. They are supported in using multiple resources and strategies for learning science *and* developing English.

Language of the Science Classroom: Moving Toward Disciplinary Language of Science

The classroom language used to teach and learn a particular subject, such as English literature, history, or mathematics, draws from the disciplinary language and discourse conventions of the subject. Many features of classroom language and of written materials are common across subjects. There are, however, language and literacy challenges and opportunities that are specific to science. If science teachers are to engage ELLs in science and engineering practices, they must have a clear understanding of the ways that students and teachers use oral and written language to interact with each other and to obtain information from written materials. They must monitor individual students' language use to ensure that all students are comprehending the discourse and participating in it.

In this section, we describe and illustrate some of the ways that language is used in the teaching of science to provide teachers with a better understanding of what is currently being referred to as academic language and academic literacy. In order to be more specific, we introduce the term *language of the science classroom* that includes the registers (i.e., styles of talk) used in the science classroom by teachers and students as they participate in academic tasks and activities and demonstrate their knowledge in oral or written forms.[5] Language of the science classroom is grounded in colloquial or everyday language but moves toward the disciplinary language of science. For example, written materials used in science classrooms rarely represent the disciplinary language of professional scientists, but rather use styles and levels of language intended for science learners. As the grade level advances, written materials intended for learners tend to mirror disciplinary language more closely. Our intent is to be explicit about what science teachers and their students "do" with language in their classrooms.

As previously described, Table 1 summarizes (a) science and engineering practices, (b) crosscutting concepts, and (c) core ideas in each science discipline. Table 2 presents the four selected

Table 2
Science and Engineering Practices and Selected Language Functions

Practices	Scientific Sense-Making and Language Use	
Develop and use models	Analytical tasks	Develop and represent an explicit model of a phenomenon or system Use a model to support an explanation of a phenomenon or system Make revisions to a model based on either suggestions of others or conflicts between a model and observation
	Receptive language functions	Comprehend others' oral and written descriptions, discussions, and justifications of models of phenomena or systems Interpret the meaning of models presented in texts and diagrams
	Productive language functions	Communicate (orally and in writing) ideas, concepts, and information related to a model for a phenomenon or system • Label diagrams of a model and make lists of parts • Describe a model using oral and/or written language as well as illustrations • Describe how a model relates to a phenomenon or system • Discuss limitations of a model • Ask questions about others' models
Develop explanations (for science) and design solutions (for engineering)	Analytical tasks	Develop explanation or design Analyze the match between explanation or model and a phenomenon or system Revise explanation or design based on input of others or further observations Analyze how well a solution meets design criteria
	Receptive language functions	Comprehend questions and critiques Comprehend explanations offered by others Comprehend explanations offered by texts Coordinate texts and representations
	Productive language functions	Communicate (orally and in writing) ideas, concepts, and information related to an explanation of a phenomenon or system (natural or designed) • Provide information needed by listeners or readers • Respond to questions by amplifying explanation • Respond to critiques by countering with further explanation or by accepting as needing further thought • Critique or support explanations or designs offered by others
Engage in argument from evidence	Analytical tasks	Distinguish between a claim and supporting evidence or explanation Analyze whether evidence supports or contradicts a claim Analyze how well a model and evidence are aligned Construct an argument
	Receptive language functions	Comprehend arguments made by others orally Comprehend arguments made by others in writing
	Productive language functions	Communicate (orally and in writing) ideas, concepts, and information related to the formation, defense, and critique of arguments • Structure and order written or verbal arguments for a position • Select and present key evidence to support or refute claims • Question or critique arguments of others
Obtain, evaluate, and communicate scientific information	Analytical tasks	Coordinate written, verbal, and diagrammatic inputs Evaluate quality of an information source Evaluate agreement/disagreement of multiple sources Evaluate need for further information Summarize main points of a text or oral discussion
	Receptive language functions	Read or listen to obtain scientific information from diverse sources including lab or equipment manuals, oral and written presentations of other students, Internet materials, textbooks, science-oriented trade books, and science press articles Listen to and understand questions or ideas of others
	Productive language functions	Communicate (orally and in writing) ideas, concepts, and information related to scientific information • Present information, explanations, or arguments to others • Formulate clarification questions about scientific information • Provide summaries of appropriate information obtained for a specific purpose or audience • Discuss the quality of scientific information obtained from text sources based on investigating the scientific reputation of the source, and comparing information from multiple sources

Note. The analytical tasks, receptive language functions, and productive language functions included in this table are selective rather than exhaustive.

Table 3
Language of the Science Classroom

Features of Classroom Language	Teachers' Language Use and Tasks	Students' Language Use and Tasks		
			Written	
	Oral and Written Receptive and Productive	Oral Receptive and Productive	Receptive	Productive
Modality	Explanations and presentations (one-to-many, many-to-many) Communication with small groups of students (one-to-group) Communication with individual students (one-to-one) Communication with parents (one-to-one)	Whole-classroom participation (one-to-many) Small group participation (one-to-group) Interaction with individual peers (one-to-one) Interaction with adults within school contexts (one-to-one)	Comprehension of written classroom and school-based formal and informal written communication	Production of written classroom and school-based formal and informal written communication • Written reports • Science journal entries
Registers	Colloquial + classroom registers + disciplinary language and terminology	Colloquial + classroom registers + disciplinary language and terminology	Science-learner written registers + disciplinary language and terminology + disciplinary discourse conventions	
Examples of Registers	Classroom registers: • Giving directions • Checking for understanding • Facilitating discussions Science discourse registers used for: • Describing models • Constructing arguments • Providing written or verbal explanation of a phenomenon or system	Classroom registers: • Comprehending oral directions • Asking for clarification • Participating in discussions Learner-appropriate science discourse registers and conventions used for: • Describing models • Constructing arguments • Providing oral explanations of a phenomenon or system	Classroom, school, and science-learner written registers: • Textbooks • Lab or equipment manuals • Writing by other students • Internet materials • Science-oriented trade books • Science press articles • Syllabi • School announcements • Formal documents (e.g., class assignment, quarterly grades, assessment results)	

science and engineering practices, types of analytical tasks that students engage in for each practice, and receptive (listening/reading) and productive (speaking/writing) language functions (see CCSSO, 2012, for all eight practices). These receptive and productive functions are what students "do" with language in order to accomplish analytical tasks. Table 2, then, unpacks the science and engineering practices presented in Table 1 and illustrates that as ELLs participate in each of these practices, they exercise certain analytical tasks to make sense of and construct scientific knowledge. Language serves as the vehicle to perform analytical tasks and ultimately to construct knowledge. Although analytical tasks and language functions are intrinsically interrelated, they deliberately appear separate in Table 2 to highlight the complexity of the language of the science classroom. To learn to perform analytical tasks and language functions over time, ELLs need access to a rich language environment in which frequent examples are part of everyday interactions.

Table 3 focuses on the language of the science classroom itself and, in column 1, highlights three key elements of classroom language use: *modality*, *registers*, and *examples of registers* in an attempt to move beyond simple definitions of "the language of science" as vocabulary or grammatical correctness. *Modality* refers to multiple aspects of the oral and written channels through which language is used. The table calls attention to the multiple features of students' and teachers' language use in the classroom while engaged in science and engineering practices. The table also makes evident that language used in the science classroom involves interactions between teacher and students, between students in small groups, by students with the entire class, and by students with various written materials. The rows labeled *Register* and *Examples of Register* highlight the various different registers used by both teachers and students to engage in interaction in the science classroom. These ways of using language range from the informal styles used by teachers to provide explanations, to the more formal, student-directed written styles used by classroom texts, and to the typical oral language used by students to interact with each other. In carrying out such practices, students grow in their ability to use appropriate registers.